PART 531 - GEOLOGY

SUBPART 531A - GEOLOGIC INVESTIGATIONS

531.00 General

Appropriate consideration of regional, local, and onsite geologic conditions is basic to sound conservation planning and engineering design in all NRCS programs. The NRCS geologist has responsibility for geologic investigations and interpretations for NRCS projects. Where state staffs lack a geologist, the state conservation engineer determines the need for and secures the services of a qualified geologist. However, depending on the needed intensity of investigation, there are conditions, as defined in this policy, under which it is appropriate for trained non-geologists to conduct site investigations.

531.01 Scope and intensity of geologic investigation

The scope and intensity of geologic investigation shall be consistent with the geologic and geomorphic complexity and stability of the site; pertinent social, economic and safety considerations; size and purpose of the structure, practice or project; kinds of construction materials to be used; and the potential for damage or loss of life if the structure or practice fails.

As a minimum, geologic investigations conducted by the NRCS shall conform to guidance in ASTM D 420, Standard Guide to Site Characterization for Engineering, Design, and Construction Purposes, to foster consistency of practice and to ensure rational, flexible planning of the investigation.

Types of geologic investigations include geologic reconnaissance, preliminary geologic investigation, detailed geologic investigation, and construction investigation (as-built).

A geologic reconnaissance described in 531.02 is required for all dam sites, and conservation practices, components of practices, or structures that involve significant ground construction activity, such as ponds, pond sealing, waste storage facilities, streambank and shoreline protection, stream channel stabilization, wetland development or restoration, and mine reclamation.

Investigations are conducted by a person holding the appropriate job-approval authority for the class of structure, as outlined in 501.04, and who is trained to recognize geologic hazards. A geologist shall conduct investigations in areas where experience or information is limited, where geologic conditions are complex or unstable; where the kinds of construction materials to be used are complex or questionable; and where the potential for damage or loss of life is high if the structure or practice fails.

531.02 Requirements for geologic reconnaissance

Geologic reconnaissance includes the collection and review of existing data; a site visit to assess engineering and geomorphic feasibility of the site; and consideration of how operation of the proposed project, structure, or practice might adversely impact local resources, particularly soil, surface waters (including the sediment-water balance), and ground water.

Before going to the field, all available pertinent technical materials, such as regional and state geologic maps, topographic maps, well logs, aerial photographs, satellite imagery, soil surveys, water quality reports, mineral resource surveys, and published and unpublished reports of the site or similar sites are reviewed.

A site visit shall be conducted to assess the engineering significance of the geologic setting, topography, site drainage, soil and rock materials, and other conditions in the area that can affect the suitability of the site for its intended use. The local physical resources in the area, including sediment, soils, surface waters, and ground water are identified, as well as offsite resources that may be impacted by project implementation. The resources are assessed in terms of the potential adverse impacts that operation of the proposed project, structure, or practice may have on them.

If the proposed structure is a dam, the reconnaissance shall include determination of whether any conditions listed in 531.25 will affect the site.

The results of the geologic reconnaissance are used to assess the need for more detailed investigation and whether additional technical expertise is needed. These needs are based on site complexity and experience of personnel in the project area. The findings, conclusions, and recommendations for additional investigation are documented as prescribed in 531.15.

Documentation includes a geologic map prepared according to 531.14. The map is filed with the geologic report.

531.03 Requirements for preliminary geologic investigations

Preliminary geologic investigation is conducted to provide sufficient information upon which reliable project cost estimates can be made in the planning phase of a project, and to determine the need for additional investigation.

All outcrops, cut banks, and other surface exposures are thoroughly inspected. Erosion conditions, landslides, seeps, springs, and other pertinent conditions in and adjacent to the watershed are examined. The information is gathered in the context of site feasibility for project implementation and engineering performance.

The need for detailed subsurface investigation must be determined. In areas of generally homogeneous soils and known geologic conditions, a detailed investigation may not be necessary for small, low-hazard structures such as farm ponds, drop structures, or chutes. For such structures, the relevant engineering characteristics of site materials and conditions need only be recognized and evaluated on the basis of experience in the area.

The investigation shall be sufficiently detailed to furnish the planning team with information for making sound preliminary designs and cost estimates.

The findings, conclusions, and recommendations for additional detailed subsurface investigations are documented as prescribed in 531.15.

A geologic evaluation map or sketch shall be included in the documentation and prepared according to 531.14. The location of all pertinent geologic features in the project area, such as rock outcrops, springs, seeps, water wells, landslides, streams, and gullies are documented.

531.04 Requirements for detailed geologic investigations

Detailed geologic investigation is conducted to provide detailed surface and subsurface information needed for sound project design, layout, construction, and safe operation of the structure or practice throughout its design life. Geologic investigations shall conform to meet all state laws and regulations.

A geologic investigation plan shall be prepared by the investigating geologist and design engineer prior to conducting a detailed investigation.

Detailed investigation includes any combination of the following:

- seismic evaluation;
- quantitative or semi-quantitative geomorphic evaluation;
- developing sediment budgets (including sediment production, transport, and yield); and
- subsurface investigation; and (5) obtaining samples for laboratory testing and performing *in situ* field tests.

All geologic conditions that may influence design, layout, construction, and safe functioning of the structure shall be investigated, characterized, and documented. Documentation shall include a geologic map prepared according to 531.14 and a geologic report that conforms to 531.15.
The tools used in subsurface investigation vary from site to site depending on local conditions, and may include geophysical surveys, such as electromagnetic, ground penetrating radar, and seismic refraction or reflection; power equipment, such as core drills, backhoes, bulldozers, and augers; cone penetrometers; and hand tools. The results of all geophysical surveys shall be verified by penetrative exploration or correlation with nearby outcrops and other physical features.

Seepage potential of the permanent pool area and dam site of water holding reservoir sites shall be evaluated.

Exploratory bore holes shall be not be left uncovered overnight. At completion of the investigation, all test pits, exploratory bore holes, and trenches are back filled in such a manner as to protect ground water quality and to remove the physical hazard to people, animals, and machinery.

531.05 Requirements for geologic investigation during construction and project implementation

Geologic investigation shall be conducted during construction and the project implementation phase on all Group I dams as defined in 531.20 to verify all assumptions and interpretations made in previous investigations and to identify differing conditions that may impact the long term performance of the structure. Differing geologic conditions that require design modification shall be documented in the as-built records.

If an unanticipated geologic condition that requires design modification is encountered during construction of any NRCS project, structure, practice, or component, the responsible field person shall notify and apprise the state conservation engineer as soon as possible. The state conservation engineer shall determine the need for and secure the services of a qualified geologist to conduct a site visit to assess the encountered geologic condition and provide interpretations and technical support for design or installation changes.

531.06 Geologic investigations of existing structures:

(a) Repair and rehabilitation

Engineering structures and practices requiring repair or rehabilitation may need additional geologic information to support design changes that may result from a change to a higher structure class, changes in criteria or standards, or a lack of specific information in the area of interest.

The determination of the adequacy of available geologic information is conducted as part of the design review process, explained in 501.05. The design engineer and geologist shall jointly determine the need for a geologic plan of investigation based on the results of the review.

Policies provided in Subpart B - Dam Site Investigations, and Subpart D - Erosion and Sedimentation Investigations, apply for geologic investigations for repair or rehabilitation of engineering structures and practices. Geologic information is gathered to address

- the needs for sound engineering design and
- the potential impacts on applicable local physical resources, including soil quality, sediment quality, ground water and surface water quality, and stream channel stability.

Investigations of impoundment structures and practices shall address the sediment pool in terms of:

- The location, type, and quality of sediment that will be affected by rehabilitation measures.
- The location, type, and quality of sediment that will be exposed to erosion and
- downstream transport.
- The location, type, and quality of sediment that will be dredged or excavated to reclaim designed water or sediment storage.
- The effects of changes in the sediment-water balance on the geomorphic stability of the stream channel downstream of the site.

The geologic report is filed with the engineering records for the repaired or rehabilitated structure or practice.

(b) Geologic investigations for decommissioning of structures

Engineering structures and practices selected for decommissioning may involve the complete or partial removal of a structure, or a change in its original design function.

The determination of the adequacy of available geologic information is conducted as part of the design review process, explained in 501.05. The design engineer and geologist shall jointly determine the need for a geologic plan of investigation based on the results of the review.

Policies provided in Subpart B - Dam Site Investigations, and Subpart D - Erosion and Sedimentation Investigations, apply for geologic investigations for decommissioning of engineering structures and practices. Geologic information is gathered to address:

- the needs for sound engineering design and
- the potential impacts on applicable local physical resources, including soil quality, sediment quality, ground water and surface water quality, and stream channel stability.

Investigations of impoundment structures and practices selected for decommissioning shall address the sediment pool in terms of:

- The location, type, and quality of sediment that will be affected by decommissioning measures.
- The location, type, and quality of sediment that will be exposed to erosion and downstream transport.
- The location, type, and quality of sediment that will be dredged or excavated.
- The effects of changes in the sediment-water balance on the geomorphic stability of the stream channel downstream of the site.

The geologic report is filed with the engineering records for the decommissioned structure or practice.

531.07 Cultural and scientific resources discovered at site

Materials discovered during site investigation or construction that may have historical, archeological, cultural, or scientific significance or value, are reported according to policy contained in GM-420, Part 401, Cultural Resources (Archeological and Historical Properties).

531.08 Erosion, sediment, and pollution control during site investigations

Criteria for erosion, sediment, and pollution control contained in 520.01 apply during geologic site investigations.

531.09 Classification of earth (geologic) materials

(a) Soil

Soil material shall be classified in the field according to the Unified Soil Classification System, ASTM D 2488, Standard Practice for Description and Identification of Soils (Visual-Manual Procedure). Samples for laboratory testing and analysis are classified according to ASTM D 2487, Standard Test Method for Classification of Soils for Engineering Purposes, as explained in 533.01.

(b) Rock

Rock material is classified by common rock type names according to a simplified geologic scheme, such as NEH Part 628, Chapter 52, table 52-1. Rock used for specific engineering purposes in NRCS work is classified by TR-71, Rock Material Field Classification System.

(c) Transitional materials

Earth material that is transitional between soil and rock is classified by its genetic category and unconfined compressive strength. Strength is estimated in the field by hardness tests given in NEH Part 628, Chapter 52, tables 52-2, 52-3, and 52-4. Transitional material that can be classified by criteria in ASTM D 2488 is considered soil for classification purposes.

531.10 Logging soil and rock

Field logs and documentation of geologic investigations should conform to guidance in ASTM D 5434, Standard Guide for Field Logging of Subsurface Explorations of Soil and Rock; and ASTM D 2113, Standard Practice for Diamond Core Drilling for Site Investigation.

531.11 Preserving, transporting, and storing soil and rock samples

Requirements conform to ASTM D 4220, Standard Practices for Preserving and Transporting Soil Samples; ASTM D 5079, Standard Practices for Preserving and Transporting Rock Core Samples; and ASTM D 2113, Standard Practice for Diamond Core Drilling for Site Investigation.

All rock cores are labeled and photographed according to ASTM D 5079 and ENG Geology Note 5. Photographs are annotated and filed with the project design folder. Policy provided in 533.11, Soil Mechanics Data Collection, applies during geologic investigation.

531.12 Disposition of soil and rock samples

The storage and maintenance of soil and rock samples cannot be continued indefinitely. However, their engineering significance and replacement costs need to be carefully considered prior to disposal.

Soil samples stored at project locations for purposes of site showings and material classification may be disposed of after completion of the construction contract.

Rock core stored at project locations for purposes of site showings and material classification may be disposed of after photographic documentation and logging of the core are completed or after completion of the construction contract.

Soil and rock samples tested at NRCS facilities may be disposed of at the discretion of the facility.

For sites with special construction or material problems, the submitting NRCS office may request the testing facility to hold the samples for a specified period. Such samples are disposed of by the facility with the concurrence of the submitting office. All soil and rock samples are stored and discarded in compliance with all applicable pest control regulations, as explained in 531.13.

Before soil samples and rock cores are discarded, they may be offered to a state geological survey or geological repository; school, college, or university geology, engineering, archaeology, or anthropology department; or any interested civil or cultural organization.

531.13 Quarantines on movement of soil samples, and soil sampling and moving equipment.

Soil movement regulations are designed to stop the human-assisted spread of agricultural pests, such as imported fire ant, corn cyst nematode, golden nematode, witchweed, and Mexican Fruit Fly. The shipping or transport of all soil samples and soil moving equipment under any NRCS activity or program shall conform to regulations of the Animal and Plant Health Inspection Service (APHIS), USDA.

Soil samples from regulated areas, shall be shipped only to USDA approved facilities for processing, testing, or analysis. The current list of regulated areas is available from APHIS:

US Department of Agriculture
Animal and Plant Health Inspection Service
Plant Protection and Quarantine Programs, Permit Unit
4700 River Road
Riverdale, MD 20737
Telephone 301-734-8896
Internet Location: Http://www.aphis.usda.gov

Soil samples from regulated areas are not sent or transported to any facility without first determining whether the receiving facility is approved by APHIS. The following NRCS facilities are approved by APHIS to receive soil samples:

National Soil Mechanics Center (NSMC) - Lincoln, NE
NSMC - Ft. Worth, TX
National Soil Survey Center - Lincoln, NE

The NSMC, Lincoln, NE is the only NRCS facility that accepts Pacific Basin and foreign soil materials.

Private facilities shall apply to the appropriate APHIS headquarters for approval in order to receive NRCS soil samples.

Land owners and operators who receive NRCS technical assistance but ship their own soil samples to private facilities must be informed of these regulations.

(a) Packaging

All soil samples from regulated areas must be shipped so that no spillage or breakage occurs in transit. Undisturbed samples in moisture-proof containers may be shipped in the usual manner. Other samples must be shipped in containers that resist tearing and puncturing. Canvas bags inside wooden or metal boxes are most desirable. Small samples may be shipped inside heavy plastic bags inside strong canvas bags, each tied separately and securely.

Soil samples taken from below a depth of 3 ft in regulated areas may be shipped as UNREGULATED samples if care is taken not to contaminate them while collecting and preparing them for shipment. If there is any question of contamination, ship as REGULATED.

(b) Labeling of samples. All samples shall be labeled with the following information: date of sample, project location (project name, county, state) depth interval of sample, sampling location number, name of securing sample.

(c) Shipment. The exterior of each shipping carton containing regulated soil samples must be clearly marked CONTENTS: SOIL SAMPLES.

(1) Domestic samples. Each sample is identified by stamping or printing the word REGULATED in red on both the inside and outside tags. Samples sent to the National Soil Mechanics Center Labs shall be identified as REGULATED on Form NRCS-ENG-534, Soil Sample List, and Form NRCS-ENG-356, Request for Soil Mechanics Laboratory Test.

(2) Overseas samples. All soil samples from any foreign source, offshore possession, or Hawaii shall be shipped under permit. Form PPQ-525 is required and is obtained from APHIS (address given in 321.14 above)

(d) Equipment used to sample or move soil

Equipment and hand tools used to collect soil samples in regulated areas shall be thoroughly cleaned of all soil residues at the collection site before removal to unregulated areas.

Soil-moving equipment being moved from regulated areas to unregulated areas shall be cleaned of all soil residues at the work site from which it is being moved. These regulations shall apply to NRCS-owned and operated equipment, as well as to the tools and equipment of drilling and earth-moving contractors.

Contractors shall be advised of quarantine requirements through the applicable clause in bid notifications and contracts as covered under GENERAL or SPECIAL PROVISIONS.

(e) Regulated counties and APHIS district offices

Contact APHIS (address above) for the current list of counties under Federal domestic plant quarantine, including address and phone number of APHIS headquarters in each state.

531.14 Geologic maps

An engineering geologic map is drawn to identify and spatially represent zones of geologic material that meet similar engineering performance criteria. In some cases, a geomorphic map, showing landforms, slope stability, and topography is appropriate. The map shows the locations of all measurements, samples, or observations, as well as the data collected. Supplements may include structural contour maps showing elevations on geologic contacts, tops of key beds, or other surfaces of interest; and isopach maps showing contoured thickness of a mapped unit. Cross-sections, profiles, fence diagrams, columnar sections, perspective drawings, and other illustrations may be used to represent geologic features.

A geologic evaluation map is a plan view diagram or drawing, representing a given area, depicting the orientation and location of key geologic and related features that could significantly affect the performance of a proposed or existing structure or practice. It may include profiles, cross-sections, or other supplemental figures to help illustrate the information. A geologic evaluation map is used to support planning documents, such as an environmental assessment or environmental impact statement.

Maps are prepared on the best available topographic base map or aerial photograph using standard signs and symbols, at a chosen scale and projection. Plane table, air photo, GPS, and conventional surveying techniques may be applied to develop a detailed geologic map.

For small structures at low hazard sites, a site sketch is considered adequate. A site sketch is drawn free-hand from observation or uncontrolled surveys showing only approximate space, scale, and orientation relationships of the main features of an area.

The accuracy and scale of a map shall be commensurate with the scope of the project and complexity of the site.

Maps drawn to scale include a graphic scale and a verbal statement using different units such as 1 inch equals 1 mile or a representative fraction such as 1:200. Maps with exaggerated vertical scales are explained with a verbal statement such as, vertical scale 10x horizontal scale.

All maps and sketches shall include a key to symbols used and a north arrow.

531.15 Geologic reports

All geologic reports of investigation are prepared, signed, and dated by the investigating geologist or person holding the appropriate engineering job-approval authority for the class of structure, as outlined in 501.04.

The general outline and contents of the report should conform to guidance presented in ASTM D 420. As a minimum, the report shall include the following headings.

Location of the area investigated. The location is given in terms pertinent to the project, and may include maps, sketches, and photographs on which test pits, bore holes, and sample areas are plotted.

Procedures. This section includes a description of the investigating procedures used, including field and laboratory testing.

Factual findings. Factual findings are clearly separated from interpretations of results. All borings and test hole logs, graphic presentation of geophysical measurements, and laboratory test results are presented. Cross sections presented with basic data from the investigation are limited to the ground surface profile and factual subsurface data obtained at specific exploration locations. Stratigraphic units between locations of intrusive locations are indicated on cross sections only if supported by continuous geophysical profiles. Cross sections that show interpretive information, such as correlation lines between locations of intrusive explorations, shall be presented separately from factual findings, and supported by explanatory notes. Potential contractors shall be provided only with factual findings.

Interpretation of results. This section includes appropriate recommendations and disclaimers for the use of the report. Recommendations for design parameters are subject to restrictions imposed by state licensing law, and shall be made only by professional engineers and geologists specializing in the field of geotechnical engineering and familiar with the purpose, conditions, and requirements of the study.

Geologic terms and symbols not specifically defined in NRCS literature shall conform to ASTM D 653, Standard Terminology Relating to Soil, Rock, and Contained Fluids; the American Geological Institute (AGI) Glossary of Geology; or current AGI Data Sheets.

531.16 Resource planning investigations and reports

In support of the conservation, development, and management of physical natural resources in Service programs, the NRCS geologist shall be responsible for:

- Providing information pertinent to resource issues of concern such as topography, soils, erosion, sedimentation, drainage, ground water quality, ground water quantity, geomorphology, geologic hazards, and mineral resources. Geologic evaluation maps are prepared as part of the documentation process.
- Determining location, quantity, suitability, and excavation characteristics of potential sand, gravel, and quarry rock resources within a project area (ASTM D 4992 provides guidance on field examination).
- Cooperating with other technical specialists and planners in locating, mapping, and documenting undeveloped geologic resources within the project area to avoid their damage, contamination, and destruction by project activities.
- Assisting in the preparation of the geology sections of soil survey reports. The geologist supports soil survey activities as explained in 533.22.
- Identifying geologic resources within a project area, including ground water, building stone, sand and gravel deposits, quarry stone, and related geologic materials.
- Identifying the potential for geologic attractions that may have scenic, educational, scientific, or similar intangible values.

SUBPART 531B - DAM SITE INVESTIGATIONS

531.20 Classification of dam sites for geologic investigation

To establish criteria for geologic investigation and sampling, dam sites are categorized into two groups according to the fill height of the structure, construction materials, purpose of structure, and structure class.

Group I dam sites include:

- All structure class c dams.
- All structure class b dams.
- All structure class a dams with a maximum fill height equal to or greater than 35 feet, as measured from low point on centerline.
- All structures greater than 20 ft high of the following types: concrete or masonry arch or gravity dams, drop spillways, box-inlet drop spillways, and chutes.
- All dams with a maximum fill height equal to or greater than 20 feet, as measured from low point on centerline, where the principal purpose is forming storage reservoirs for recreation, municipal water supply, or irrigation and where the product of the storage (ac-ft) times the height (ft) of the dam is equal to or greater than 3,000.

Group II dam sites include all other types of dams that do not classify as Group I, such as embankment structures of Conservation Practice Standards 378, Pond; Waste Storage Facility, 313; and Grade Stabilization Structure, 410.

531.21 Requirements for geologic investigation of Group I dam sites

All preliminary, detailed, and construction (as-built) site investigations shall be conducted under the supervision of a qualified geologist.

A qualified geologist is defined as an individual who meets the minimum requirements for the practice of geology as defined by the State Board of Registration of the state in which the individual resides. In the absence of state registration requirements or a state definition of geologist for the practice of geology, a qualified geologist shall meet the requirements for the title of Certified Professional Geologist, as defined by the American Institute of Professional Geologists.

Subsurface exploration shall be of sufficient intensity to determine all conditions that can influence the design, layout, construction, and functioning of the proposed structure.

Before the investigation is completed, the geologist, the engineer designated for soil mechanics leadership, and the design engineer shall jointly review the findings of the investigation to determine the adequacy of the sampling program for testing. The data are reviewed for adequacy for use in all stages of design and construction.

An engineering geologic map of the site shall be prepared according to 531.14.

All soil and rock units shall be characterized beneath the entire base of the structure and abutments. For all earth fill dams in Group I, borings at all stations within the footprint of the structure shall be extended to depths equal to or greater than the equivalent proposed height of fill associated with the points of boring, or to hard, massive, unaltered rock or similar limiting layer. Borings shall be extended deep enough into rock to establish whether it is *in situ*.

For all concrete dams, borings shall extend to depths equivalent to at least 1.5 times the proposed effective height of the dam as measured from the maximum proposed depth of excavation.

All geologic materials and features with engineering significance at or near the site are characterized, documented, and assessed according to current industry standards. Characterization includes classification and determination of material properties and mass properties, especially stratigraphic and structural discontinuities, such as faults, joints, and fractures with engineering significance.

Sufficient borings are made along the proposed centerlines of drop inlets or other conduits to provide correlation of geologic materials from the riser to the outlet and to a depth equal to the zone of influence of the structure.

Sufficient borings are made along the proposed centerline of dams to provide correlation of geologic materials and to define the rock surface profile.

At least one bore hole is placed at the riser, at the intersection of the centerlines of the dam and conduit, and at the outlet.

Delineate the incompressible rock surface where it occurs within the depth of influence of the structure.

Locate earth material proposed for use as fill and determine its quantity and engineering suitability using appropriate soil mechanics tests, as needed.

Determine the depth to ground water, seasonal variation of water table, and extent and character of aquifers within the zone of influence of the structure.

Evaluate the need for controlling ground water during construction and determine the need for controlling moisture content in borrow material.

Evaluate whether economic mineral deposits, including sand and gravel, occur within the area of influence, or would be preempted or otherwise impacted by the project.

Evaluate excavation characteristics of materials in proposed open spillway cuts.

Assess the influence of rock mass properties on the slope stability of rock materials in the spillway cut slopes.

Investigate earth auxiliary spillways according to 531.25 d.

Evaluate the need for hydraulic pressure testing in rock foundations and abutments of proposed dams for water storage reservoirs.

531.22 Requirements for geologic investigation during construction of all Group I dam sites.

Requirements for geologic investigation during construction and project implementation, explained in 531.05, apply to all Group I dam sites.

A geologic investigation is conducted by a geologist during construction of all Group I dam sites, defined in 531.20. Throughout construction the project engineer shall notify the geologist as geologic materials become exposed during excavation of pipeline trenches, structure foundations, core trenches, auxiliary spillway cuts, and borrow areas. The geologist shall visit the site as often as necessary to assess the engineering significance of all differing conditions encountered during construction excavation.

The geologist shall prepare an as-built geologic report. All findings and interpretations that differ from those reported in previous geologic investigations shall be identified and explained. Differing conditions with engineering and geomorphic significance are, to the extent possible, measured and assessed in the field, and documented in the report. The report shall include logs, cross-sections, engineering geologic maps, and photographs, as needed, to support the documentation. Maps and report shall conform to 531.14 and 531.15, respectively. The report is filed as a supplement to the engineering design folder of the project (explained in 512.52 b).

Documentation includes revising as-built drawings, geologic maps, and structure sections prepared in earlier investigations. The documentation process may include photographic or video recordings, hand sketches, or supplemental topographic or GPS surveys, as appropriate.

531.23 Requirements for geologic investigation of Group II Dam Sites

Requirements for geologic investigation are determined by a person holding the appropriate job-approval authority for the class of structure, as outlined in 501.04, and who is trained to recognize geologic hazards. A geologist is consulted in areas where experience or information is limited, or geologic conditions are complex.

531.24 Requirements for logging soil and rock at Group I dam sites

(a) All Group I dam sites for sampling soil and rock at all Group I dam sites:

- Representative samples are obtained for classification purposes of all geologic materials identified in the foundation, borrow, relief well, principal spillway, and auxiliary spillway areas.

- Undisturbed samples for shear tests are obtained from all strata of fine grained soils of questionable stability in the foundation within a depth equivalent to one-half the maximum fill height of the dam, as measured from low point on centerline.

(b) All Group I dam sites that have permanent storage. For all Group I dam sites in which storage other than sediment pool storage is to be incorporated into the design and in which significant leakage is suspected:

- Samples are obtained of materials underlying the permanent pool area to determine reservoir sealing requirements.

(c) Structure class a, b, and c dam sites. For all structure class a dam site that have a maximum fill height equal to or greater than 35 ft, and for all structure class b and c dam sites:

- Samples for compaction and shear tests are obtained from the borrow areas and auxiliary spillway areas.
- Undisturbed samples for consolidation tests are obtained of all compressible fine grained materials from the foundation within a depth equivalent to the maximum height of the dam (as measured from low point on centerline). If compressible materials are suspected to occur at greater depths, drilling and sampling of the compressible materials are conducted to depths within the zone of influence.

(d) Group I dam sites that have a maximum fill height greater than 20 ft Undisturbed samples for compaction tests are obtained for all materials of questionable shear strength, such as soft clays and soft silts, in the foundation of the dam.

(e) Other Group I dam sites for any other type of Group I dam site not listed in 521 (a-d):

- Samples for compaction tests are obtained from borrow and auxiliary spillway areas if information and experience in the area are inadequate to conclusively predict the engineering behavior of the materials.

531.25 Requirements for logging soil and rock at Group II dam sites

For all Group II dam sites, samples are not required if adequate information and experience in the area are available. If such information and experience are unavailable or if questionable conditions occur, sampling is conducted the same as for Group I dam sites.

531.26 Conditions that require investigation for all dam sites

A geologic investigation is required if any of the following conditions occur, regardless of dam site classification. The intensity of investigation explained in 531.01 and detail of the report shall be consistent with the structure class of the dam, complexity of site geology, and data needed for design.

(a) Seismic Assessment. All dams in seismic zones 3 and 4, Alaska, Puerto Rico, Virgin Islands, and Hawaii, and all structure class c dams in seismic zone 2 require special investigations to determine liquefaction potential of cohesionless strata, including very thin layers, and the presence at the site of any faults determined to be active in Holocene time. The potential for earthquake induced seiches of the reservoir pool shall be evaluated. A map shall be prepared indicating the location of all intensity V or magnitude 4 or greater earthquakes of record, and any historically active faults within a 100 km (65 mi) radius of the site. The geologic report also shall summarize any other possible earthquake hazards, such as ground compaction, landslides, and excessive shaking of unconsolidated materials. For slope stability analysis, earthquake information, including acceleration, duration, and recurrence interval, is collected from the US Geological Survey

(USGS internet address is http://www-nmd.usgs.gov). Seismic hazard maps for certain regions are available in printout form by contacting:

National Geophysical Data Center
NOAA, Mail Code E/GC
325 Broadway,
Boulder, CO 80303
Telephone (303) 497-6215
Internet Address: info@ngdc.noaa.gov

(b) Subsidence. Assess the potential for ground surface subsidence caused by past or future extraction of solid minerals or fluids, including ground water and natural gas.

(c) Collapsible Soils. Evaluate the potential for collapse upon saturation or wetting of certain unconsolidated materials associated with deposits such as, alluvial fans, terraces, and eolian materials in arid and semiarid regions. If the potential exists, investigate and conduct appropriate sampling for laboratory analysis to provide quantitative information for design and construction.

(d) Earth Spillways. For all Group I dams as defined in 531.20, the geologist provides specific geologic information to the design engineer for the stability analysis and integrity analysis of auxiliary spillways, as explained in NEH Part 628, Chapters 50 (Earth Spillway Design) and 51 (Earth Spillway Erosion Model, SITES program). All earth materials occurring beneath the spillway down to the elevation of the flood plain are mapped by the headcut erodibility index according to NEH Part 628, Chapter 52, Field Procedures Guide for the Headcut Erodibility Index. The investigation shall be sufficiently detailed to provide all input parameters for the index, and shall include a plan view map and longitudinal sections. The investigating geologist and responsible engineer jointly determine the engineering significance of all material that has a headcut erodibility index less than or equal to 10.

(e) Mass Movements. Assess landslides and landslide potential at dam and reservoir sites and summarize the history of mass movements in the project area.

(f) Karst Areas. Evaluate limestone, dolomite, gypsum, and other soluble rocks at dam and reservoir sites for subsidence potential and leakage potential.

(g) Multipurpose Dams. Evaluate the ground water regime and hydraulic characteristics of the entire reservoir area of water storage dams to determine leakage potential and the need for reservoir sealing.

(h) Other. Evaluate other geologic conditions or materials that have engineering significance. These include, but are not limited to, dispersive soil; soil containing highly soluble sodium salts; expansive soil; gypsiferous soil; soil that has vertic properties; gap-graded soil, sensitive clay; highly compressible soil; pyritic shale; fissile shale; stress relief and rebound joints; and shallow artesian ground water.

531.27 Investigation of water storage reservoir sites

Geologic investigation shall be conducted in the proposed reservoir area, abutments, and embankment foundation to evaluate leakage potential.

Evaluate anticipated changes in the ground water regime with respect to the intended function of the structure.

Evaluate potential effects, including damages, of seepage from a reservoir on lands adjacent to or downstream from the structure.

531.28 Dams subject to deep subsidence

Special investigations are required for the planning and design of dams and spillways subject to deep foundation subsidence that can result from collapse of underground mines, or extraction of fluids, such as water, oil, and natural gas from beneath the Earth's surface. The required foundation supports established in this subpart are essential to the design of safe embankments.

This policy applies where foundation subsidence is or could be a threat to the safety of all structure class b and c dams and all class a dams for which the product of storage (ac-ft) times effective height (ft) of dam is greater than 3,000.

(a) Geologic formations containing layered mineral deposits

At all dam sites underlain by layered mineral deposits that may be mined in the future, certain minimum foundation support shall be provided for earth embankments and associated spillways. Provision for such support may be accomplished through fee simple title or subordination agreements that insure the legal right to:

- Prevent the development or removal of such minerals from unmined areas that would cause subsidence of the structure, or
- Preserve or build and maintain adequate support to ensure against future subsidence of the structure foundation for mined areas.

At the ground surface, surface and subsurface landrights shall encompass an area that extends outward beyond the base of the dam a horizontal distance equivalent to the depth of the deepest mineral deposit below ground surface. This requirement may be modified as a result of a detailed site specific study by, and at the consequent recommendation of, a qualified consulting mining engineer.

Fee simple title or subordination agreements may or may not be required for the area of the reservoir upstream of the dam that is beyond the area required for the stability of the dam. The need for the legal right to control the mining of the reservoir area depends on the following types of evaluation:

- An evaluation by the sponsors or owners of their possible liability for damage to:
  - the mine or mining operation caused by flooding, increased pumping costs, a reduction in amount of the mineral that can be removed, or other possible damage; or
  - surface areas and improvements on the periphery of the reservoir that may subside and thereby suffer increased damage, such as, from inundation or increased flood flow in inlet channels.

If any of the problems listed above occur, NRCS will advise the sponsors or owners in writing to:

- Seek legal counsel and a qualified mining engineer to help determine the extent of the risk the sponsors or owners should assume;
- Consider purchasing necessary landrights to protect against possible damage suits;
- Consider the feasibility of taking easements to an elevation higher than normal by an amount equal to or greater than the anticipated subsidence. NRCS shall make available to the sponsors or owners all of its data pertinent to the subsidence problem and the proposed dam.

(b) Geologic formations containing fluids

During the planning phase of projects involving dams to be designed and constructed under NRCS programs, a geologist shall determine whether removal of fluids such as petroleum, water, and natural gas could impact the design, function, and safety of the dams, particularly by abrupt differential settlement. The geologist shall provide recommendations to the design engineer on identified geologic concerns that need to be addressed in the operations and management plan for the structure. Subordination of mineral rights within a limited area at the site does not necessarily prevent subsidence of the structure.

If studies indicate that the predicted subsidence cannot be remedied, the site shall be abandoned.

SUBPART C - HYDROGEOLOGIC INVESTIGATIONS

531.30 General

Appropriate consideration of project hydrogeology is essential in the conservation planning, development, operation, and maintenance phases of many NRCS programs. Investigations for the development of ground water resources, the management of ground water quality, and engineering control or management of underground water are conducted under the supervision of the NRCS geologist and coordinated with other disciplines, as appropriate. Depending on the needed intensity of investigation and complexity of the site, there are conditions, as defined in this policy, under which it is appropriate for a person holding appropriate engineering job-approval authority for the class of structure, as explained in 501.4, to conduct site investigations.

531.31 Investigations for ground water resources development

Technical guidance for ground water development is contained in NEH 18, Ground Water; NEH 631.33, Investigations for Ground Water Resources Development; EFH, Chapter 12, Springs and Wells, Ground Water Manual (Bureau of Reclamation, 2nd ed., 1995). Other methods not described in these references may be considered at the discretion of the investigating geologist.

The NRCS geologist has responsibility for the following types of investigations and evaluations:

- Evaluating ground water development potential of aquifers.
- Conducting ground water budget analyses in watersheds and evaluating ground water overdraft potential.
- Evaluating ground water quantity, quality, and geologic factors that influence design and construction of production wells, and well head protection measures.
- Estimating ground water consumption or demand in watersheds.
- Evaluating potential for underground disposal of surface waters.
- Evaluating potential for conjunctive use of ground water with surface water supplies.
- Determining aquifer boundary conditions and potential for well interference.
- Determining aquifer recharge potential.

531.32 Investigations for ground water quality management

Guidance on ground water quality investigations is in NEH 651, Agricultural Waste Management Field Handbook.

The NRCS geologist has responsibility for the following types of investigations and evaluations to provide sufficient information for planning or design:

- Aquifer restoration or enhancement.
- Location, construction, rehabilitation, decommissioning, and problem investigations of water wells.
- Ground water pollution potential relative to agricultural point and nonpoint sources.
- Potential for ground water pollution by components of agricultural waste management systems.
- Influence of karst terrace on construction and performance of conservation practices and structures.
- Well head protection zones.
- Areas having ground water recharge potential.
- Location of ground water divides and delimiting recharge areas in karst terrane and other highly pervious geologic materials.
- Saline seeps.
- Saltwater intrusion.

531.33 Ground water investigations for conservation engineering

The NRCS person holding the appropriate engineering job-approval authority for the class of structure, as outlined in 501.04, is responsible for conducting the following types of investigations and evaluations to provide sufficient information in the planning or design phases of a project:

- Investigations for controlling the water table with respect to:
  - agricultural drainage and irrigation water management activities;
  - engineering drainage for excavation de-watering of foundations, borrow areas, quarries, buildings, and mines;
  - seepage evaluations for blankets, drains, filters, and grouting;
  - engineering subdrainage for slope stability.

Technical guidance for investigation of the water table are in EFM Chapter 14, Drainage; NEH 16, Drainage.

A geologist is responsible for:

- Evaluating engineering performance of conservation practices or components by employing ground water quality monitoring, sampling, and testing methods, practices, or geophysical techniques according to current standards in:
  - ASTM, Section 04, Construction, Volumes 04.08 and 04.09 on Soil and Rock;
  - ASTM, Section 11, Water and Environmental Technology, Volumes 11.01 and 11.02 on Water.
- Investigations for the treatment or remediation of sinkholes and other karst
- features.
- Evaluating ground subsidence associated with ground water withdrawal.

SUBPART 531D – GEOMORPHIC, EROSION, AND SEDIMENTATION INVESTIGATIONS

531.40 General

Appropriate consideration of geomorphic processes, including sediment production, transport, and deposition, is essential to sound natural resources conservation planning and engineering. It also is essential to the proper installation and performance of many conservation practices and structures. The effects of natural and anthropogenic sources of erosion and sedimentation, both onsite and offsite, are assessed in all NRCS programs. Geomorphic processes and their impacts on resource conservation activities that are assessed by the geologist include, but are not limited to:

- Sediment storage design for reservoirs and ponds
- Sediment yield and sediment budgets of watersheds
- Reservoir sedimentation
- Surface water quality degradation by sediment
- Structural deficiencies caused by sedimentation and erosion
- Stream channel and stream corridor function including erosion and deposition
- Evaluation of rock for erosion control.

531.41 Responsibility for erosion and sedimentation investigations

The state conservationist is responsible for ensuring that interdisciplinary study teams include specialists for the geomorphic issues under consideration.

A qualified geologist is responsible for the survey, and analysis and interpretation of data related to geomorphic processes. These processes include detachment, transport, deposition, consolidation, cementation, and lithification of soil and rock particles.

Because of the complexity of geomorphic processes, particularly those pertaining to sedimentation and erosion, many modern field procedures and predictive

models are still under development or refinement. Sound technical judgment, therefore, is requisite in the consideration of process relationships, the selection of field techniques to be used in studies, and the formulation of hypotheses.

The NRCS geologist shall, in collaboration with related technical specialists, develop supplemental guidelines and geomorphology field procedures consistent with the state's needs, as determined by the state conservation engineer.

531.42 Sediment storage design for reservoirs and ponds

Design criteria for the allocation of sediment storage in all reservoirs impounded by Group I dams as defined in 531.20, shall be determined by a geologist. For Group II sites, the determinations may be made by others who have been trained by a qualified geologist in recognizing and evaluating the effects of sedimentation on pond performance. A specialist with expertise in sedimentation is consulted for Group II dams with complex sedimentation problems or for Group II sites where data are to be applied to another area or site.

Methods to be used are provided in NEH-3, Ch. 8, Sediment --Storage Design and Criteria. These methods include the gross erosion/sediment delivery ratio, measurement of sediment in similar ponds and reservoirs, suspended load records of gauged streams, and direct predictive equations. Other methods not described in NEH-3 may be considered at the discretion of the investigating geologist.

Reservoir trap efficiency is calculated using procedures outlined in NEH-3, Ch. 8. Other methods not described in NEH-3 may be considered at the discretion of the investigating geologist.

531.43 Watershed sediment yield studies

Watershed sediment yield and sediment budget studies are conducted to evaluate the effectiveness of land treatment and structural measures in reducing erosion and sediment yield in the treated area. They also are conducted to provide basic data for planning and design of soil and water conservation measures.

Methods for determining watershed sediment yield are provided in NEH-3, Ch. 8. Other methods not described in NEH-3 may be considered at the discretion of the investigating geologist.

531.44 Reservoir sedimentation surveys

Reservoir sedimentation surveys are conducted on selected reservoirs for specific purposes determined by the state conservation engineer.

Sedimentation surveys for Conservation Practice Standard 378, Pond, are conducted by personnel trained in sedimentation surveys. Sedimentation surveys for Conservation Practice Standard 402, Dams, are conducted by a geologist.

Sedimentation surveys conform to procedures in NEH-3, Chapter 7, Field Investigations and Surveys. Other proven methods are used at the discretion of the investigating geologist. The data collection format conforms to ASTM D 4581, Standard Guide for Measurement of Morphologic Characteristics of Surface Water Bodies.

Reports for each reservoir sedimentation survey are prepared according to requirements in NEH-3, Chapter 7, and are filed at the state office with a copy sent to the Director, CED.

The report includes data on watershed conditions that affect sediment yield, for examples, soils, surface geology, topography and land forms, land use and treatment, and all types of significant erosion. The report includes information about land use management changes through time in the contributing watershed.

The state conservation engineer is responsible for the technical adequacy of the report.

531.45 Sedimentation investigations related to quality of surface waters

A qualified geologist is responsible for the development of sediment budgets that identify sources and sinks and allocate sediment by sources. Sediment budgets identify sediment particle size ranges by source. Problem identification is specific as to the sediment particle sizes causing problems.

Water quality standards as they pertain to turbidity have been established by the states for interstate and coastal waters under provisions of the Water Quality Act of 1965.

Related policy on sedimentation as it pertains to surface water quality is contained in USDA nonpoint source water quality policy, Department Regulation 9500-7 (460-GM, Apr. 1987).

Guidelines and standards for investigating, analyzing, and evaluating sediment as related to quality of surface waters are provided in consensus industry sources, including:

- National Handbook of Recommended Methods for Water-data Acquisition, and
- ASTM, Section 11--Water and Environmental Technology, Volumes 11.01 and 11.02 on Water.

Other pollutants associated with sediment-related water quality are investigated, analyzed, and evaluated by a specialist that has appropriate expertise.

The state conservation engineer collaborates with other technical disciplines and is responsible for developing supplemental guidelines and field procedures consistent with program needs of the state.

531.46 Investigation of structural problems caused by sedimentation or erosion

Policy contained in 504, Subpart A provides requirements for investigation of structural problems caused by sedimentation and erosion, and provides for committee assignments; procedures; and engineering reports.

If sediment accumulation in a pond, reservoir, or other sediment retaining structure appears to significantly exceed the design rate and may result in functional limitation during its design life, a sedimentation investigation is conducted at the discretion of the state conservation engineer. The investigation addresses the extent of the problem and causes of the increased sedimentation rate, and outlines possible solutions.

A sedimentation study is part of investigations made of structural problems caused wholly, or in part, by channel instability as presented in 531.47.

531.47 Geologic investigation of sedimentation and erosion processes in the stream channel and stream corridor

Geologic investigations may include analyzing sediment transport capacity of the channel, determining change in transport capacity caused by the planned modification, and determining bedload sediment sources. Stream channel investigations may consider the dimension, pattern, profile and other pertinent geomorphic factors of the stream, as well as activities in the watershed that can affect sediment supply and subsequent stream channel behavior and stability.

Investigations are conducted under the supervision of a qualified geologist. Investigations consist of logging, mapping, sampling, testing, and analysis of bed and bank material, and collection of specific fluvial geomorphic data according to policy contained in Subpart A - Geologic Investigations.

Intensity of investigation shall conform to policy outlined in 531.01. Stream channel classification, analyses, and interpretations for predicting the behavior of the channel and riparian area that have alternative designs take into full consideration fundamental principles and modern theories of fluvial geomorphology. Recommendations for design give full consideration to channel stability concepts for natural streams that allow a stream to develop a dimension, pattern, and profile that will be in dynamic equilibrium over the life of the project.

Technical guidance is contained in NEH Part 653, Stream Corridor Restoration Handbook; EFH, Chapter 16, Streambank and Shoreline Protection; and NEH-3, Sedimentation.

531.48 Evaluation of rock for erosion control

Rock material is commonly used in erosion control applications as filter bedding stone, riprap stone, armor stone, and breakwater stone, and in groin and gabion structures.

The intensity of evaluation of rock material to be used for erosion control depends on the size and design requirements of the individual project, the quantity and quality of rock required, and the potential risk for property damage or loss of human life.

The acceptability of an identified source of rock material may be based on experience and previous performance of use for similar applications under comparable performance conditions.

The assessment of questionable sources of rock to be used for erosion control is conducted according to ASTM D 4992, Standard Practice for Evaluation of Rock to Be Used for Erosion Control and other related ASTM standards.

531.49 Special erosion and sedimentation studies

A geologist or other appropriate technical specialist is consulted for certain events that typically occur infrequently and that may present either opportunities or problems associated with, but not necessarily limited to, physical damages caused by erosion and sedimentation on coastal, estuarine, flood plain, and wetland areas, and reservoir rehabilitation or decommissioning. They may be associated with wind action, surface and underground mining, irrigation, and gullies, including ephemeral gullies. Damages may be related to sediment intrusion into fish-spawning gravel beds. Damages may occur in urban and rural areas due to uncontrolled storm water runoff from recently burned wildfire areas.

Special erosion and sedimentation studies are conducted according to policy contained in Subpart A - Geologic Investigations.